equilibrium, it is transferred to a weighing apparatus at the end of each tension step to estimate the moisture content.

The main disadvantages of this method are:

1. Disturbance to the fragile soil matrix (larger pore structure) due to regular handling of the soil sample.
2. Inaccurate soil moisture estimation due to sample handling.
3. High labour intensity. Regular supervision is necessary to determine the equilibrium points.

It would be useful to at least partially automate the test procedure to eliminate or reduce the drawbacks. An added advantage of an automated system could be the ability to produce accurate outflow data to estimate the unsaturated hydraulic conductivity.

SUMMARY OF INVENTION

In broad terms, in one form the invention comprises a soil moisture content measurement system comprising a porous plate arranged to support a soil sample; a hanging water tube extending downwardly from the porous plate, the tube arranged to convey liquid toward and away from the porous plate; a measuring capillary tube in connection with the hanging water tube, the measuring capillary tube arranged to convey liquid toward and away from the hanging water tube; measurement apparatus configured to measure the movement of liquid within the measuring capillary tube; and a data memory configured to receive and store data from the measurement apparatus representing liquid movement measurements within the measuring capillary tube.

In broad terms, in another form the invention comprises a method of measuring soil moisture content comprising the steps of supporting a soil sample on a porous plate; positioning a measuring capillary tube with respect to the porous plate to enable liquid to be conveyed between the measuring capillary tube and the porous plate; measuring the movement of liquid within the measuring capillary tube; and storing in a data memory data representing liquid movement measurements within the measuring capillary tube.

BRIEF DESCRIPTION OF THE FIGURES

Preferred forms of the moisture release curve calculation system and method will now be described with reference to the accompanying Figures in which:

Figure 1 is a preferred form system of the invention;

Figure 2 shows a hardware user interface apparatus forming part of the system of Figure 1;

Figure 3 shows a software user interface forming part of the system of Figure 1;

Figure 4 shows a set up window from the interface of Figure 3;

Figure 5 shows a collect data window from the interface of Figure 3;

Figure 6 shows a status panel forming part of the interface of Figure 3;

Figure 7 shows a manual control button forming part of the interface of Figure 3;

Figure 8 illustrates sample raw data from the system of Figure 1; and

Figure 9 shows a typical soil moisture release curve

The hanging water tube 60 is also fitted with a suitable sample valve 140 to control the flow of water from the water tank 100 travelling into and up the hanging water tube 60, and to control the flow of water exiting the tube 60. A drain valve 150 is arranged to control the flow of water out of the supply tube 120 and the hanging water tube 60.

A measuring capillary tube 160 is connected to the ends of the hanging water tube 60 and the supply tube 120. The horizontal measuring tube 160 is vertically positioned with respect to the soil sample 50 by a distance "d" in order to apply tension to the soil sample 50. It is envisaged that the distance "d" can be varied in order to alter the applied soil water tension on the soil sample 50. The distance "d" could be varied by enabling the measuring tube 160 to be raised and lowered with respect to the soil sample 50 using a stepper motor (not shown) in order to apply different soil water tensions to the soil sample.

The measuring capillary tube 160 is preferably substantially horizontal and parallel to the porous plate 40 and is fitted with measurement apparatus to measure the displacement of water along the tube 160 in either direction. It will be appreciated that the measuring capillary tube could be positioned substantially vertically or alternatively could be positioned at any angle to the horizontal.

In one form, the measurement apparatus includes a series of infrared emitters 165 positioned on one side of the measurement tube 160, together with a series of corresponding infrared detectors 170. The emitters 165 and detectors 170 are preferably arranged as corresponding pairs. Modulated infrared beams at 40 kHz are transmitted from the infrared emitters 165 to the infrared detectors 170 through the measurement tube 160.

It is envisaged that part of the measuring tube 160 will contain water and that a meniscus appears at the intersection between the part of the tube 16 filled with water and the part of the tube that does not contain water. The meniscus will travel along the measuring tube 160 as water enters or exits the tube 160.

The apparatus also includes several button controls, for example 'Bypass the current tension step' 208, 'Start the test' 210, and 'activate the Display' 212. The functions of these controls are described below.

The display 206 on the hardware user interface 180 could further include a series of LED displays 214. The number of LED displays illuminated indicates the number of water segments in the measuring tube 160 from Figure 1 that are full of water. For example, if 4 LED displays are illuminated, then 4 segments in the measuring tube 160 are full of water, with each segment containing approximately 0.1ml of water.

In order to obtain drying and wetting moisture release curves of a soil sample, the system 10 from Figure 1 is placed through one or more purging, drying, and wetting cycles.

The intention of the purging cycle is to remove air bubbles from the tubes 60, 120, 160, the porous plate 40, and the water reservoir 35. Referring to Figure 1, the distance "d" is minimised by, for example, raising the measuring tube 200 to an upper limit. The valves 140 & 150 are closed and the valve 130 is opened to fill the measuring tube 160 with de-aired water from tank 100. Then the valves 140 and 70 are opened and valve 130 closed, allowing water and trapped air bubbles in the tubes to flow through the tube 60 along the spiralled water channel in the sealed water reservoir 35 to escape through the air valve 70.

It is envisaged that this purging process be repeated 20 times or in any case enough times so that the water volume through the system is replaced in all the tubes.

Following the purging cycle, a drying cycle imposes a tension on the soil sample 50 by lowering the measuring tube 160 to a height corresponding to the tension required to remove water from the soil sample. The measuring tube 160 is first emptied, by opening the valve 150 leaving all other valves closed. Valve 150 is closed as soon as the water meniscus inside the measuring tube 160 reaches the first infrared sensor at the right end of the measuring tube 160. With all other valves closed, the valve 140 is then

CLAIMS:

1. A soil moisture content measurement system comprising:

a porous plate arranged to support a soil sample;

a hanging water tube extending downwardly from the porous plate, the tube arranged to convey liquid toward and away from the porous plate;

a measuring capillary tube in connection with the hanging water tube, the measuring capillary tube arranged to convey liquid toward and away from the hanging water tube;

measurement apparatus configured to measure the movement of liquid within the measuring capillary tube; and

a data memory configured to receive and store data from the measurement apparatus representing liquid movement measurements within the measuring capillary tube.

2. A soil moisture content measurement system as claimed in claim 1 wherein the porous plate is elevated with respect to the measuring capillary tube.

3. A soil moisture content measurement system as claimed in claim 2 wherein the extent of elevation of the porous plate above the measuring capillary tube is adjustable.

4. A soil moisture content measurement system as claimed in any one of the preceding claims further comprising:

a liquid receptacle elevated with respect to the hanging water tube and/or the measuring capillary tube; and

a supply tube extending downwardly from the liquid receptacle, the tube in connection with and arranged to convey liquid to the hanging water tube and/or the measuring capillary tube.

5. A soil moisture content measurement system as claimed in any one of the preceding claims further comprising a microcontroller associated with the data memory,

the microcontroller configured to control movement of liquid between the hanging water tube and the measuring capillary tube.

6. A soil moisture content measurement system as claimed in claim 5 wherein the data memory and microcontroller are connectable to a computer device.

7. A soil moisture content measurement system as claimed in claim 6 wherein data stored in the data memory is transferable to the computer device.

8. A soil moisture content measurement system as claimed in claim 6 or claim 7 wherein commands are transferred from the computer device to the microcontroller.

9. A soil moisture content measurement system as claimed in any one of the preceding claims wherein the measurement apparatus comprises a series of infrared emitter and infrared detector pairs spaced along the measuring tube.

10. A method of measuring soil moisture content comprising the steps of:

supporting a soil sample on a porous plate;

positioning a measuring capillary tube with respect to the porous plate to enable liquid to be conveyed between the measuring capillary tube and the porous plate;

measuring the movement of liquid within the measuring capillary tube; and

storing in a data memory data representing liquid movement measurements within the measuring capillary tube.

11. A method of measuring soil moisture content as claimed in claim 10 further comprising the step of positioning a hanging water tube to convey liquid between the porous plate and the measuring capillary tube.

12. A method of measuring soil moisture content as claimed in claim 10 or claim 11 further comprising the step of transferring data stored in the data memory to the computer device.